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Co-producing UK climate change adaptation policy: An analysis of the 2012 and 2017 UK Climate Change Risk Assessments

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ABSTRACT

This paper explores the use and perceived usefulness of the 2012 and 2017 United Kingdom Climate Change Risk Assessment (CCRA) reports to identify potential areas of improvement for UK adaptation policy. We conducted interviews with key stakeholders and analysed each CCRA in the context of objective, audience, budget, frame, key findings, dissemination, and how they informed policy. We found that stakeholders used the CCRA in three main ways: (i) to make a business case for their work; (ii) to shape direction of policy or work; and (iii) practical applications. Our findings suggest that the way in which both CCRAs have been operationalized are symptomatic of the UK state reinforcing scientific reductionism in adaptation assessments for policymaking. Recommendations from interviews for future CCRAs included (i) adopting more innovative methodological approaches, (ii) developing more effective mechanisms for operationalisation of the CCRAs, and (iii) improving communication of the CCRAs, their risks and recommendations. This would enable better alignment with user needs and more robust inclusive decision-making processes in the assessment of future UK climate risks and impacts. We discuss how a new framework is needed in which evidence assessments such as the CCRA can be further developed utilising methods of co-production.

1. Introduction

As the human and physical effects of climate change continually increase, so has policy attention to climate adaptation (Massey and Huitema, 2016; Vogel and Henstra, 2015). This has significant spatial planning challenges and scientific uncertainties attributed to it (Bell et al. (2018); Vij et al., 2017) and the UK has arguably been a significant forerunner in implementing robust adaptation policy in comparison to other countries, given the implementation of the 2008 Climate Change Act (Benzie, 2014; Biesbroek et al., 2010; Brown et al., 2018; Lorenz et al., 2017; Massey and Huitema, 2013). However, when the UK Department for Environment, Food and Rural Affairs (DEFRA) launched its second UK Climate Change Risk Assessment (CCRA) in 2017, though this was the most comprehensive assessment of climate risks in the UK to date, the launch was given relatively little publicity by the UK Government, unlike the inaugural CCRA in 2012. This suggests that climate change adaptation has not been given the necessary policy attention as previously reported in the academic literature (Massey et al., 2014; Massey and Huitema, 2013) or at least it has been hindered by wider political forces going on in the UK most recently, like Brexit (Rayner and Jordan, 2017).

Given the 10 year anniversary of the UK Climate Change Act, it is timely that we take stock of progress with respect to climate adaptation policy. Using a critical discourse analysis of the 2012 and 2017 CCRAs, evidence on the process for compiling the CCRAs and interviews with relevant stakeholders involved in each CCRA, we explore how CCRAs have been undertaken. The process in which CCRAs have been compiled and the way climate information/knowledge has been utilised is particularly significant given the emergence of a literature grounded across the social sciences and cognate disciplines that questions the types of knowledge used in formulating climate policy, the most significant being the prevalent use of more globally reductive forms of scientific knowledge to determine future climate projections (Demeritt, 2001; Hulme, 2011, 2010). It has been argued such epistemic knowledge use has prevented more reflexive, communicative local knowledge that is co-produced through relevant governance systems being used

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more to determine the types of climate policies needed to mitigate climate impacts and reduce human vulnerabilities across different spatial jurisdictions as dangerous climate change ensues (Beck, 2011; Hinkel, 2011; Howarth and Painter, 2016; Jasanoff, 2010; Kythreotis, 2018; Kythreotis et al., 2013). Hence, our comparative analysis of the 2012 and 2017 CCRAs specifically examines the forms of knowledge, process and types of users used in each assessment to critically demarcate the significant role of co-production in producing more effective evidence-based adaptation policy in the UK. This is important given the ambiguous role of the UK central government's relationship with forms of polycentric governance within recent UK adaptation policy formulation (Gillard et al., 2017).

Section two briefly summarises the background to adaptation policy in the UK since the 2008 Climate Change Act came into force. Section three compares the 2012 and 2017 CCRAs in terms of objective, audience, budget, frame, key findings, dissemination, and how they have informed (adaptation) policy. Section four examines the use, usefulness and potential for improvements in the CCRAs going forward. In assessing the CCRAs, this paper adds new policy insights into how future adaptation frameworks like the CCRA can be improved further in terms of co-production and greater user inclusivity. This in turn will catalyse more effective, evidence-based adaptation policy and practice in the UK.

2. Brief background to UK adaptation policy

The following section briefly discusses how UK adaptation policy has evolved since 2008. For a more comprehensive background for adaptation as a policy field, see Massey and Huitema (2013); Massey et al.(2014) or Lorenz et al. (2017). Driven by the Stern Review on the Economics of Climate Change (2006), the UK was one of the first countries to introduce "a risk-based approach into climate change legislation" to address unavoidable climate change impacts (Brisley et al., 2012: 5). Over the last decade, UK climate policy has principally evolved out of the legally binding Climate Change Act of 2008, which set specific strategies on climate mitigation and adaptation. The Act set out a procedure to conduct a Climate Change Risk Assessment (CCRA) every five years, which would highlight associated risks and opportunities from future climate change (Committee on Climate Change, 2008). The first CCRA was published in 2012. Other related initiatives emerging out of the Act included a new independent advisory body, the UK Committee on Climate Change (UKCCC) who would, inter alia, review CCRA processes and procedures. The Act also gave the UK Government an Adaptation Reporting Power (ARP) to direct other organisations, 'Reporting Authorities' to prepare reports on the current and future risks and opportunities from climate impacts on that organisation; and their proposals for adapting to a changing climate (DEFRA, 2012). The evidence-base of climate risks and opportunities reported from the first CCRA in 2012 led to the statutory implementation of the UK National Adaptation Programme (NAP) in 2013. NAPs also enabled Local Authorities (LAs) to start to build local capacity with non-state stakeholders in planning for climate change. However, this was done on a voluntary basis, confirming previous critiques of NAPs for their lack of co-ordination, stakeholder involvement and having unclear divisions of responsibilities (Biesbroek et al., 2010).

Nevertheless, in 2010 DEFRA also established the Local Adaptation Advisory Panel (LAAP) to enhance capacity on local adaptation by providing a policy link between central and local governments (DEFRA, 2011). With the Environment Agency, in 2011, DEFRA also part-funded Climate UK, a network of state and non-state organisations supporting climate action across the UK, suggesting that central government was relinquishing a degree of control over local adaptation planning and practice, whilst maintaining financial control over the UK local adaptation policy agenda. Yet a transition from more centrally orchestrated adaptation governing to local co-production (non-state and state) governance was short-lived, due to the abolition of some major adaptation programmes that supported local adaptation planning and practice (e.g. Climate Ready and Climate UK ended in March 2016 due to central government financial constraints, Committee on Climate Change, 2017a p.18; Salvidge, 2016). The LAAP functions also changed from supporting local adaptation action to informing policy to feed into the NAP (Committee on Climate Change, 2017b). These represent significant changes in the relationship between national adaptation policy agenda setting and the practice of local adaptation planning and governance. With local adaptation planning and governance suffering from such budget cuts, evidence of best practice, risks and opportunities remained communicated mainly through the national CCRAs in the UK. As such, we feel it pertinent to undertake a comparative assessment of the UK 2012 and the 2017 CCRAs with respect to objective, audience, methodology, budget, frame, key findings, dissemination, and how they informed policy, as a means to highlight the ever-changing landscape of adaptation policy and practice in the UK today.

3. Comparing the 2012 and 2017 Climate Change Risk Assessments

The UK CCRA sets out the main priorities for climate change adaptation in the UK and the NAP with a vision of "A society which makes timely, far sighted and well-informed decisions to address the risks and opportunities posed by a changing climate" (DEFRA, 2013: 11), and outlines thematic policies and actions to meet these ends. The 2017 CCRA acknowledged key limitations in the 2012 CCRA which subsequently informed the methodology and development of the former, notably that it 'assessed the potential impacts of climate change without taking account of current adaptation plans and activity', that magnitude and confidence scores were used to summarise results and that UK impacts of domestic and international risks of climate change were not included (Humphrey and Murphy, 2016: 8). The 2017 CCRA Synthesis Report summarises some of the differences compared to the previous CCRA as do each of the chapters in the 2017 CCRA Evidence Report. The approach adopted, content and structure of the 2012 and 2017 Climate Change Risk Assessments is outlined in their components that feature in the body of their reports, methods adopted, the review process and outputs produced (Table 1).

Due to methodological changes, the 2012 and the 2017 UK CCRAs are not comparable as such. As explained by the Adaptation Sub Committee's (ASC) 2014 *Method Document* for the UK CCRA Evidence Report 2016, this has primarily been caused by a significant budget cut from the £3 million allocated for the first CCRA to under £1 million for the second (ASC, 2014). As a result, the UK CCRA 2016 Evidence Review is "underpinned by a large body of peer-reviewed scientific literature and grey literature" and acknowledges the associated difficulties, namely evidence gaps associated with uncertainties. With the financial support of the UK Natural Environment Research Council (NERC), the ASC commissioned four research projects to contribute to an assessment of the evidence and "help in translating existing research into a usable format" (ASC, 2014: 3) to inform the second UK CCRA. These projects focused on projections of flood risk in the UK (Sayers et al., 2015), water availability in the UK (HR Wallingford et al., 2015), impact of climate change on UK's natural assets (AECOM, 2015), and developing climate change scenarios (Wade et al., 2015). As a result, the evidence-base commissioned by the ASC, and which underpinned the 2017 CCRA, relied on different, un-standardised assumptions about baseline data, the degree of climate change and impacts, socio-economic responses and adaptation processes. To address this issue, the ASC developed a new methodological (primarily qualitative) approach focusing on a literature review, in addition to results from the four research projects and expert judgement mainly used "to assign confidence and urgency scores [to the evidence as well as the risks], and also to characterise future adaptation efforts in many cases" (ASC, 2014: 5).

The methodological change adopted would also address data, policy

Table 1
Comparison of methodological approach for CCRA 2012 and CCRA 2017 (Adapted from Humphrey and Murphy, 2016).

Aspect of report	CCRA 2012	CCRA 2017
Risks and opportunities	> 100, from a list of 700	~60, selected by government and report authors
Metrics for summarising results	Focus on magnitude	Focus on urgency
Time periods covered	2020s 2050s 2080s	Current 2020s 2050s 2080s Post 2100 (for sea level rise)
Analysis type	Mix of existing data and new analysis to create 'response functions' for risks and opportunities	Mostly synthesis of existing analysis with some new data from four specially-commissioned research projects
Climate science use	UK Climate Projections UKCP09 To explore different climate scenarios	UKCP09 Global CMIP5 model ensemble Single-models Other scenario-based approaches
Consideration of drivers of risk	Excluded effects of planned adaptation of socio-economic change beyond population growth	Included analysis of effects of adaptation and socio-eco change on risk/opportunity where evidence exists
Spatial coverage	England Northern Ireland Scotland Wales	England Northern Ireland Scotland Wales International dimension
Outputs	11 sector reports 1 synthesis report 3 national summaries	1 synthesis report 1 evidence report 4 national summaries 4 research reports
Authors	Consultants (HR Wallingford) Signed off by DEFRA	Independent academics Consultants (led by ASC) Signed off by ASC
Cost	£3 million over three years	£650 K over three years
Funders	DEFRA Devolved administrations	DEFRA Devolved administrations Natural Environment Research Council Environment Agency
Peer review process	DEFRA-led stakeholder review process Method: Adaptation Sub-Committee Sector reports and evidence report: independent peer review Method and outputs: DEFRA Science Advisory Council	DEFRA-led stakeholder review process ASC-organised workshops and conferences on method and outputs Chapters and synthesis report: independent peer review and external review by organisations Method: DEFRA Science Advisory Council and Economic Advisory Panel.

and audience needs, particularly to allow readers to understand advances in the evidence since the first UK CCRA (ASC, 2014: 4), to reflect "on the extent to which the risks have changed as a result of actions taken under the [NAP] and beyond" (DEFRA, 2013: 13). The aim of the UK CCRA Evidence Report 2016 was to address a single, policy-relevant question about the urgency of further action: "Based on the latest understanding of current, and future, climate risks/opportunities, vulnerability and adaptation, what should the priorities be for the next UK National Adaptation Programme and adaptation programmes of the devolved administrations" (Committee on Climate Change, 2017b). In comparison, the aim of UK CCRA 2012 "to undertake an assessment of the main risks (both threats and opportunities) posed by climate change that will have social, environmental or economic consequences for the UK" (Baglee et al., 2012: 3) is broader and less specific. In this endeavour, the UK CCRA Evidence Report 2016 targeted a smaller number of risks and opportunities (approximately 60 risks and opportunities are assessed by UK CCRA 2017, as opposed to over 100 in UK CCRA 2012). It presents results primarily in terms of the urgency of further action in the short-term as well as "the magnitude of risks and potential impacts in the long-term"(Committee on Climate Change, 2016, p. 48). These methodological changes may be linked to budget constraints but greater specificity and a robust alternative approach may also facilitate clearer communication of the evidence so that it is credible, robust, and relevant, and can be used more widely to inform adaptation decisions made by Government and other stakeholders (ASC, 2014: 5). A number of climate risks to the UK were assessed by leading academics and other experts as part of the Evidence Report 2016 ranging from flooding and heatwaves to water scarcity and ocean acidification. In assessing the magnitude of risks and the urgency of additional action the following are taken into account: risks to the UK from climate change overseas; cross-cutting risks relating to the capacity of communities, businesses, infrastructure providers and national and local government across the UK to act early and effectively; changing vulnerability to climate change impacts; and steps already underway, or expected to be, across the UK to adapt.

As previously discussed, the implications of using qualitative and/or judgement-based data could include the findings being subject to accusations of subjectivity and inaccuracy due to the inherent differences in assumptions and measurement and methodological frameworks utilised by secondary sources and their authors. However, the threefold approach employed by the ASC: a literature review combined with four research projects and the use of expert knowledge and understanding should have helped to ensure that the Evidence Report 2016 drew on a comprehensive, relevant and balanced evidence base.

Given the gap between the amount of evidence available and end user needs, we have discussed the ability of the 2012 and 2017 CCRAs to actually determine the state and direction of adaptation policy in the UK. The 2012 CCRA was initiated by the UK Government at the time as a means "to embrace long-term planning and better understand risks, backed up by the best evidence, including horizon-scanning and science" (Government, 2012: 5). Yet there is increasing academic evidence that using scientific evidence on climate change to inform adaptation

policy can be epistemologically problematic (Dessai et al., 2009; Howarth et al., 2016; Preston et al., 2015), and this is even before thinking about the institutions and types of governance that are needed to implement such epistemic scientific knowledge informed adaptation policy across different spatial jurisdictions (Beck, 2011; Huitema et al., 2016; Kythreotis et al., 2013; Kythreotis and Bristow, 2017). There is a body of work that cites the benefits of using other social, political, cultural and even historical narratives beyond more deterministic global epistemic expertise to inform adaptation practice at other spatial scales, particularly the local (Adamson et al., 2018; Adger et al., 2013; Hulme, 2011, 2010; Jasanoff, 2010; Kythreotis, 2018; McEvoy et al., 2013; Paschen and Ison, 2014).

With respect to the UK CCRAs, Brown et al. (2018) argue how the second CCRA has used a science-led approach to its work. This in itself, whilst intended to be more robust with respect to using a wider evidence-base to inform policy decisions, was still based upon the magnitude of climate impacts under low, medium and high projections using the 2009 UK Climate Projections. Such projections epitomize the way in which reductive science has determined policy responses to mitigation through Intergovernmental Panel on Climate Change (IPCC) reports which foreclose other alternative social and cultural epistemologies and reinforced a techno-managerial science-policy process (O'Lear, 2016). The process of CCRA formulation with respect to adaptation policy is also unfolding through a reductive risk-based framework based on scenario model building, cost-benefit analyses and urgency scores vis-à-vis more socio-culturally equitable co-production methods that place citizens affected by climate impacts at the centre of adaptation decision-making. This reductive risk framework approach has proved highly problematic for governments to implement effective adaptation policy measures given the complexity of interrelating socio-political and cultural factors coupled with temporal uncertainty in how physical climate impacts are manifested (Adger et al., 2018). It also perpetuates historical and existing institutional policy structures for climate adaptation that forecloses alternative iterations in policy pathways of adaptation response (Adamson et al., 2018). Conversely, other work has cautioned against overusing social and cultural local knowledge, arguing for greater hybridity between different forms of knowledge – scientific and lay – to determine appropriate adaptation responses to flooding (e.g. Haughton et al., 2015; Lane et al., 2011). In light of these complex science-policy arguments, we next examine the use, usefulness and potential for improvements in respective 2012 and 2017 CCRAs to reconcile some of the major disparities between using the correct and best available evidence to meet end-user needs and requirements for future adaptation policy and practice in the UK.

4. The UK 2012 and 2017 CCRAs: use, usefulness and potential for improvements

4.1. Methodology

To examine use, usefulness and potential for improvements in the CCRAs, data was collected from 27 UK stakeholders through semi-structured interviews, a format which follows a general set of questions aimed at enabling interviewees to be free to respond as they please with limited restriction by the questions set. Key stakeholders were sampled from three pre-defined categories (see Howarth and Monasterolo, 2016): Policy communities (involved in formulating policies and decisions on climate change), Practitioners (involved in implementation of climate-related solutions or decision making processes on the ground), and Academia/Science. The geographic coverage of interviewees was UK-wide however the majority of these were located in London and the South/South-East of England. Efforts were made to secure an even representation across the three categories and recognising the breadth of work that can contribute to delivering resilience in respect to managing and responding to climate risks, to include individuals that are directly or indirectly, involved in decision-making processes. Individuals were approached based on their knowledge, expertise and experience of decision-making in relation to climate change, impacts and adaptation. This was determined based on an assessment of the literature, review of UK organisations and institutions, attendance lists to high profile climate adaptation-related events and network contacts. In addition, a snowball technique was employed by asking interviewees for their recommendations of others with relevant insights to contribute to the research.

A total of 27 interviews were carried out, with an even split across policy (n = 9), practitioners (n = 9) and academic/science (n = 9) communities; female interviewees accounted for 30% of the total (n = 8) whilst male interviewees accounted for 70% (n = 19). Organisations represented by interviewees included: universities and academic institutions, government departments and agencies, government funded independent bodies and organisations, local government, a water utility company, an infrastructure consultancy, local resilience forums, flood forums, partnerships, an insurance company, and a transport organisation. Interviewees had a range of backgrounds and experiences including: climate and weather science and forecasting, social science, communication, flood and coastal risk management, resilience, community engagement and community projects, policy, research and development, insurance and risks. The interview adopted a semi-structured format to maximise openness and flow of discussion and explored the following themes:

1) How the CCRA is used or seen as useful in decision-making;
2) Reflections on the 2012 and 2017 CCRAs
3) Areas for improvement

Interviews were treated as anonymous and confidential, within the bounds agreed. Interviews were conducted in May 2017 with the majority conducted over telephone or Skype. Interviews were audio-recorded (following consent of interviewees) using a digital Dictaphone and transcribed. A quality assurance process was applied whereby each interview transcript was reviewed by the interviewer and then sent to the interviewee for accuracy and verification. Interview transcripts were coded using a combination of inductive and deductive coding. Three randomly selected transcripts (one from each category) were analysed to refine a draft set of emergent themes and sub-themes for coding and analysis. A parallel assessment was conducted to test the robustness and validity of the emerging coding strategies. Following reflection and refinement, the main themes and sub-themes were agreed. Interviewees were assigned individual identifier codes to guarantee their anonymity, these were specific to the pre-defined category they were assigned to: Policy (PO1, PO2 etc.), Practitioner (PRA1, PRA2, etc.) and Academic (ACA1, ACA2, etc.).

4.2. Use and usefulness of the CCRAs

Just under half of the interviewees had contributed to the CCRA in some way whether it be leading the writing of the report (PO4), inputting into the science (AC1), feeding into the evidence (PR7), contributing to the energy sector report, communication and summary documents (AC2), to the international chapter (AC5), and to the Evidence Report that underpins the 2017 report (PO7), and providing a response (PO3). The CCRA is used by the majority of the interviewees in three key ways. Firstly, it is used to demonstrate a business case for adaptation as the CCRA is seen as authoritative by diverse audiences, it can be a powerful tool to highlight the importance and need to prioritise work. It has been used in communications with a variety of audiences, to establish the need for action, for example its contents and key findings were used in a letter to the UK Secretary of State (PR4) and in wider communication with the public to attempt to reduce apathy to flood risk and climate change. It has been helpful to contextualise work on climate, enabling focus on points of intersect or interest with others sectors to deliver win-win situations (PO7). More specifically, it

provides context to a number of sectoral recommendations for responses and adaptation, demonstrating a business case internally, as it clearly identifies a need for this work (PO3).

"*We use it very much as part of our informing the public to try and cut through the general apathy that there is within the public of actually the flood risk that they're at and the impact of climate change. (…) we often quote the work of the committee, for example, in a recent letter to the Secretary of State around surface water subsystems for new developments we quoted the report.*" (PR4)

"*The value in it for me is the fact that it's a kind of externally validated statement of where climate risks are at for the UK. So it has that kind of authority. So it's very useful for example in certain reports to say, this is the opinion of a group of experts that's been peer reviewed*." (PR3).

Secondly, the CCRA is used to help shape policy or work; it identifies key priority areas that need addressing and provides a focus and a focal point to those particular issues (PO9) such as food security (PR7). The CCRA helps to set a direction for work providing a formal statement of risk, this is especially important for government bodies so that their work is aligned with what national government accepts and recognises. The application of this is particularly relevant in the risks identified in CCRA which are used to set direction for the National Adaption Programme (PO7) and indirectly through government highlighting a need for more research in a particular area e.g. heatwaves (AC7).

"*We do use it in the sense that when we see where the risks identified, that does inform what we might want to invest more in, researching the climate of. So for example, if it's flooding has come out as a very high risk then it's very clear that there is a requirement for us to be better at modelling extreme rainfall events…..One of the reasons I'm doing so much work on food security is because the climate change risk assessment has picked up the fact that we don't really know how much the UK will be exposed to fluctuating food prices as a fault of climate change. (…) So I don't know if that means using it, but it does change our perspective of how serious or how significant changes in climate are*." (PR7)

"*It sort of underpins our policy, it's one of the things that helps drive forward how we do things*." (PO3)

Thirdly, the CCRA is used in designing practical application of climate responses. It has been used to understand the impacts of climate change which could increase or exacerbate the vulnerability of a system or infrastructure, for example. Its findings have been built into tools, models and frameworks to inform decision-making to build resilience to climate impacts, ensuring a greater degree of precision and scrutiny. It has been used in the design of permanent hard engineering structures particularly in cities (AC4), in the mapping of UK risk assessment in London (AC8), and as a resource and summary of the evidence base (PO7). It becomes embedded in decision-making processes and supplements advice given to drive, design and implement solutions and responses to climate impacts.

"*Use it at a very high empirical level (…), it helps us to understand where the impacts are for … when we're building our flood defences so we build that sort of detail into our model*" (PO1)

"*It's embedded within lots of our work so it's embedded in the advice we give to local planning authorities on how to make decisions over spatial planning and development in the floodplain so they have to look at climate change*." (PO6)

The CCRA is viewed as a useful piece of work which provides a more simplified perspective of a complex issue which, traditionally, is scientifically heavy, and informs broader decision-making on climate adaptation in the UK.

"*I really like it, I think the approach is very useful, it's very pragmatic and it simplifies what can become a very complex and sort of scientific data-driven process*." (AC5)

"*The UK climate impact assessment has a particular purpose to it which is to inform our national adaptation strategy*." (PO2)

It provides clear insights into a wide range of datasets, portrayed in a number of ways to depict the complexity of the data in a more simplified way. In addition it highlights very clearly the key risks the UK is exposed to which is particularly praised by practitioner interviewees

"*It's very good. They have some really good data (…).They bring together narratives and then evidence base, and sometimes commission stuff, and they'll have a view. I don't always agree with the view, but they'll have a view on something, and that's quite useful. So, they have charts that's useful and things like that*." (PR1)

"*One of the things that the CCRA did quite well I thought was to highlight the priority risks and the key risks. Again, that's quite useful to be able to point to that and say, you know, as the CCRA point out, flooding is the number one risk in the UK. So it's that kind of thing rather than detail which I think it's really useful for*." (PR3)

Whilst the CCRA is used to inform decision-making and responses to climate change by a range of participants, some stated that they do not use it. It has been recognised and seen as authoritative in delivering up to date and robust evidence on climate risks to the UK, however it is not always seen as relevant to some organisation's specific business functions, it has a UK-specific focus and has specific timescales, and uses different mechanisms for conducting research.

"*It doesn't affect what we do necessarily, we're aware of it, in effect, you know, we put our efforts into making sure we map and model the world as it is today*" (PR5)

"*…our focus is on overseas, so there's no reason why we would. I know the UK assessment does have an international bit but there were many sources of that data so it all wouldn't necessarily look to that*." (PO2)

"*Not directly, to be honest. We mostly look at forecasting and warning timescales, so in our terminology, that's about up to two weeks in advance of an event, so where most of our work and our products are being focused on*." (AC7)

"*We don't use it directly but we do use something else the government produces, the National Risk Assessment which is slightly different. It takes a shorter outlook, a five year outlook. (…) Climate change risks are typically fairly far away and our risks are much closer and we are trying to bridge the gap there*." (PR6)

A number of minor issues have also been raised in regards to the appropriateness of some methodologies used by the latest CCRA. For example, the 2017 CCRA Evidence Report identified bias in some of the observed flooding data which PO4 asserts can potentially overestimate risk. In addition, challenges also exist in ensuring vulnerability is appropriately incorporated into economic Cost Benefit Analysis appraisals to inform flood risk management decision-making, as it is considered difficult to know whether approaches assessed are adequately addressing this in order to avoid creating further inequality (PO6). The use of external research methods has also been raised as potentially inappropriate as evidence produced may not be robust enough to influence government decision-making in the intended way e.g. due to over claiming or an aspect of method not being fully adequate (PO9).

In addition, interviewees raised questions around issues of quality and value for money of producing the CCRA. This is particularly the case when different parts of the CCRA (as described above) were delivered by different organisations meaning the writing and underlying evidence base are not fully consistent. Similarly the extent to which it is used varied depending on the motivation for using its findings and implementing these within the different timescales required by stakeholders contrasted with those outlined in the report.

"*I had a look at the latest one. I know some of the people who were involved in different bits of it and the quality varies substantially probably because the underlying science is of varying quality*." (AC3)

"*There is a slight sense in which I'm not sure that was particularly good value for money. Why do we spend all that money doing it? I'm more*

Table 2
Interview respondent's comparisons of 2012 and 2017 CCRAs.

	2012 CCRA	2017 CCRA
Methodology	• Production of substantial new research • Well-defined methodology	• More academic & considered stronger on technical methods • Draws on existing literature • Considers wider evidence-base
Stakeholder engagement	• Extensive involving formal engagement with end-users	• Considered more user-friendly and less technical • Easier for non-experts to understand
Content	• Clear structure • Very technically driven • More focused on magnitude of different risks	• Good presentation of information (e.g. uncertainties) • Greater focus on urgency of actions to address risks • Magnitude or assumptions on risks not always consistent • Consistent outcomes on urgency
Recommendations	• Lacks clarity on policy recommendations	• Better designed to provide more direction for policy

familiar with what happened with the first one, 2012 one, we did a risk assessment because this is what you do but it is really clear that actually what substantive decisions rest on it? Not least of which because of the time scale for that is different than for … most emergency planning operates on a five year time frame." (AC3)

"*It is hard to say whether that is useful because it like we are working on 25 year horizons, we never actually got there yet to demonstration whether we were right or not.*" (PR10)

4.3. Comparing and improving the two versions: 2012 vs 2017

A comparison of the two versions of the UK CCRA (Table 2) was expressed as a necessary endeavour to explore the progress made in the five-year window between the first and second (AC8), the trends that may emerge, what has been addressed, and what has not worked well (PO9). For example, progress can be seen to be made with Property Level Resilience (PLR), as more is known now and it has become more of a mainstream activity than it was before (PO3). Methodological differences were noted between the two versions (AC2; AC5; PO2; PO4; PR3) yet views ranged on the relative merits of the two versions, though the two were seen as complementary (AC2). The first version benefitted from its clear structure and the production of a lot of new research under a well-defined methodology, involving formal engagement with end-users e.g. energy and transport sectors, and a formal process of risk prioritisation (AC2). It was also very technically driven, including extensive work on climate scenarios, modelling impacts, and consideration of a wide range of hazards (AC5); it was more focused on the magnitude of different risks, but was found to be lacking in terms of clarity on its recommendations for government policy (PO4). The second version benefited from using a more academic approach drawing on existing literature and enabling a wider set of evidence to be brought in rather than being constrained by a closed method (AC2). It is considered to be stronger on technical methods and presentation of information such as uncertainties (PO2), and it is considered more user-friendly and less technical with a more straightforward, intuitive approach and, using an expert-drive qualitative assessment, making it cheaper and easier for non-experts to understand (AC5). Overall it is seen as having a greater focus on the urgency of actions to address the risks outlined, although magnitude or the assumptions made are not necessarily consistent across all risks, yet outcomes in term of urgency are consistent (PO4). In addition a key aspect is that it appears to be better designed to provide more direction for policy (PO4) leading to some interviewees taking the view that the latest report is the best to use (e.g. PR3, AC4). Building on this, interviewees suggested three important areas in which the Climate Change Risk Assessments could be improved: methodology, operationalisation and communication (summarised in Table 3).

4.3.1. Methodological improvements

The evolving nature of science, means there is a need for continual updates/improvements, and therefore, to some extent, the CCRA 2017 is already out of date (PO7). In terms of methodology, there are a number of technical improvements that can be made (PO2) such as improving the approach for estimating the number of properties at risk going forward which would not be protected through strategic schemes (an issue which is being reviewed (PO3)). In addition, building on methodological developments to improve the underpinning approaches used to develop the assessments with the use of new bespoke research, going beyond the production of the assessment through external consultancy, at very early stages (AC2). Whilst this would provide a more innovative approach to building on the existing CCRAs and incorporating more up to date techniques and methods for modelling data, building scenarios and plotting risks, this is subject to funding and resource available (AC2).

"*There's a third way of doing it which we haven't done yet, which is a new bespoke research specifically focusing on the CCRA question, the climate change risk assessment question in a wider way than just in a consultancy way, I think the consultancy method applied existing techniques; what we haven't done is developed new techniques and new understanding to underpin the next risk assessment, (…). It's the usual thing you need to convince the powers that be that this is the right thing to do. I think the government would like to see that but of course it's who*

Table 3
Recommendations on how to improve future CCRAs.

Methodological improvements	• Improve approach to estimate number of properties at risk • Improve underpinning approaches used to develop the assessments: use new bespoke research, going beyond the production of the assessment through external consultancy, at very early stages • Adopt innovative approach to building on existing CCRAs and incorporating more up to date techniques and methods for modelling data, building scenarios and plotting risks
Operationalisation	• Focus on the local and city levels to help guide decision-makers on climate resilience and solutions • Provide more clarity on responsibility(ies) for response • Identify impacts at operational level • Provide more specific, sector and stakeholder-focused recommendations • Identify and build on interlinkages to better align with decision-making processes
Better communication	• Clearly demonstrate why it is useful and to whom, especially to those outside of government • Provide clearer explanation of difference between long-term climate change and climate variability • Address language barriers to make reports less academics and more accessible

pays for it isn't it, and kind of will the research councils pay for it or members pay for it? So things are under way to try and make something like this happen but it's still at very, very early stages." (AC2)

4.3.2. More operational

A recurring theme in the interviews was the need to make the CCRA more operational, particularly with a focus on the local level to help guide decision-makers on climate resilience and solutions. For example, more interlinkages are required as currently the report is still felt to be too decoupled from decision-making processes, which presumes that the science production comes first followed by decision making processes (AC3). In a number of places, it covers a range of responsibility areas with less clarity on responsibility for response, making it hard to then influence change. It would therefore benefit from more specific recommendations as currently the recommendations made are perceived as too big and broad making it difficult to pinpoint what is required (PO9).

More precisely, additional information is needed on the impacts of climate risks at an operational level, for example, on vegetation and waste treatment and specifically how to plan for these where more granular understanding of the impact of heatwaves on people and infrastructure could add value. The report needs to be made fit for purpose to direct and support actions to build resilience and to advise how to adapt and prepare for such risks in order to reduce any downstream impacts. This is particularly relevant when considering the onset of some of the risks outlined in the report, for example, to ensure that power supplies and drinking water are available during flooding events (AC4). It was also found to inadequately address (particularly in Chapter 7) the risks to UK cities such as London where the UK's key financial investments are likely to be at risk of climate destabilisation. This is further exacerbated when residents in the areas lack awareness of these risk. It was seen as disappointing that the CCRA did not directly address this (AC8).

"*I think that is thinking it through to the next level of iteration or operation (…).. We now routinely think about what it is going to mean maybe for meteorology and hydrometeorology but it is almost then thinking through if we do have that massive heat wave or drought or we have that massive flood, how does that then impact on kind of people, services, infrastructure, so we could do a bit more planning about that.…We know some of these things are coming and we should think about our practices to maybe involve them slightly so they are more fit for purpose to help people become a bit more resilient rather than just assuming it down to the people that take action. Be that thinking about how we issue warnings or manage beds for heat waves…*" (AC4)

Conversely, the point was also made that while local level information is critical to inform adaptation decisions, the remit of the CCRA is to provide a summary of the evidence of risks at the national scale. Therefore it is not solely the responsibility of the CCRA to improve, rather to explore how subsequent documents, such as the National Adaptation plan, and the work around economics and resilience can be built upon to incorporate these issues (PR3). In addition, shorter term considerations within CCRA are important and could indeed be helpful in helping to plan resilience to climate change in future, this may not in fact be fully fit the purpose of the document (PR6).

4.3.3. Better communication

There was some consensus that the CCRA needs to be better communicated in order to explain why it is useful and to extend its reach, especially to those outside of government (PO2). It needs to provide clearer explanations of the differences between long-term climate change and climate variability in order to avoid misunderstandings regarding expectations for short-term weather (AC2). The summaries provided and the top six priorities were felt, by some, to omit important information contained deeper in the report (AC8) although the final report was seen as too cumbersome at 200 pages (PO9) and too academic in nature, making it too technical for public consumption, which calls for simpler messaging (PR4).

"*Better communication of it although I should think, well probably less than 0.1% of the population of the UK has ever even heard of it. So better communicating it, explaining why it's useful. I think it's used in government a lot but outside of government.*" (PO2)

"*… it's actually in the parliamentary records that when there was a very severely cold winter a few years ago and Heathrow was closed for example, it actually, they did say they thought there wouldn't be any more cold winters because of climate change and they did actually mention the UK climate protections which are part of the Climate Change Risk Assessment as a justification for this, but it was based on a misinterpretation because these things are supposed to be a longer term trend towards milder winters over decades, it doesn't mean that now we're expecting fewer cold winters now you see. We need to be careful to make sure that people are aware of the difference between climate variability and long-term climate change and I think we can do more on that in a climate change risk assessment.*" (AC2)

5. Conclusion

This paper has compared the 2012 and 2017 CCRAs to identify potential areas of improvement for future UK adaptation policy. Using a combination of research methods we found that the 2017 CCRA was still underpinned by highly reductive science like modelling and risk-based analyses, although there were also qualitative judgments made by experts through the peer review process of the 2016 evidence report. Arguably, the use of previous modelling (UKCIP09) was largely a cost-saving issue due to the substantially diminished budget for the 2017 CCRA in comparison to the 2012 CCRA. However, being heavily quantitative data-led, the second CCRA process has enabled policymakers to take a more top-down approach to adaptation policymaking than the 2012 CCRA, which had been criticised for being too participatory-focused, convoluting central government's ability to make evidence-based policy decisions based on urgency (Brown et al., 2018). In this sense, the 2017 CCRA represented value for money from a government's point of view, although some of our interviewees were still sceptical of its true value to their own organization.

Financial constraints remain a key issue for the UK government being able to deliver the most robust suite of adaptation actions possible. Devolution coupled with budget cuts means that Local Authorities are in no position to address the risks identified in the 2017 UK CCRA, as there is no capacity - people or funds - to address local adaptation needs (Kythreotis and Bristow, 2017; Porter et al., 2015), and devolution has resulted in slightly different approaches to assessing climate risks and implementing policy actions. This is where methods of co-production can be used to fuller effect, enabling the government to save more money locally by bringing in a greater array of governance actors more attuned to local conditions who can make decisions, or at least have greater legitimacy in gathering an evidence-base of what works, and more importantly, what does not, at the local level (Howarth et al., 2017). This would also make communication pathways less opaque between government and non-government end-users of the CCRA.

Other interviewees highlighted that their use of the CCRA was limited as it was not relevant to their business function and they were operating at different timescales. The majority of interviewees however used the CCRA to make a business case for adaptation, to shape direction of policy or work and for practical application. With this in mind, a range of recommendations were made by the interviewees, based on their own assessment of the use and usefulness of the CCRAs and the comparison between the 2012 and 2017 reports.

1 Building on the range of methodological approaches adopted for the reports, further improvements were suggested to enable a more

granular application, a better incorporation of wide ranging evidence and providing space for the incorporation of more innovative techniques and methods for modelling data. This would lead to a better assessment of the number and type of infrastructure and properties at risk from climate impacts and incorporating more stakeholder input at very early stages of assessment development.

2 Mechanisms for operationalisation of the CCRA are needed to build on existing interlinkages between risks and sectors to improve decision-making. This would provide a wider range of scales of focus of operationalisation (e.g. local, city) to help guide decision-making to better fit with end user needs leading to better clarity and alignment of responsibilities for response.

3 Better communication of the CCRAs and key risks and recommendations are required to demonstrate how the reports can be most useful to specific audiences (which should be defined). This would help address language barrier issues which currently serve to alienate users of the CCRAs and can confuse decision makers rather than to inform and make the reports more accessible to non-expert audiences.. The use of expert jargon has certainly ostracised particular stakeholders from the adaptation policy process, reinforcing this notion of pragmatic state-authoritarianism that forecloses processes of co-production and polycentric governance in climate adaptation policy implementation in the UK.

In reflecting on our overall findings, we suggest that relevant UK government policymakers adopt a new framework to help navigate some of the process issues that we have identified in this paper regarding UK CCRAs and subsequent adaptation policy. Whilst defining such a framework is beyond the scope of this paper, the main issue ascertained from our interviews revolves around the need for a more heuristic examination of the epistemic complexity that has tinged climate science-policy processes over the last decade. A new framework will need to be underpinned by a more transparent information gathering approach that gives more credence to reflexive, context- and place-specific co-produced knowledge(s) above and beyond deterministic science-policy framings. Such a framework needs to be underpinned by robust institutions operating across jurisdictional policy scales in the UK that can absorb different kinds of climate knowledge more easily. This will enable government and non-government sectors alike to more fully address the inherent temporal, scalar and socio-political uncertainties brought about by short- and long-term climate impacts.

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